Thermozone® Technology
Optimized air curtains

Thirty years of air curtain development in the demanding Scandinavian climate has given us a unique platform to create air curtains with optimal door protection. Thanks to the Thermozone technology, the performance can be precisely adjusted to obtain an air curtain with efficient separation that is also comfortable to pass through.

Thermozone air curtains are optimized in:

- Airflow geometry
- Performance
- Sound level

Airflow geometry
Based on fifty years' experience of fan technology we have developed air curtains with the lowest possible sound levels and turbulence – without compromising efficiency. Our highly skilled technicians, considerable experience, and one of Europe's most modern air and sound laboratories have all contributed to what we consider to be the optimal combination of all the components in an air curtain.

Performance
Impulse and air velocity are very important factors when talking about air curtain performance. The same impulse can be obtained in different ways and a higher impulse does not necessarily mean that the air curtain is more efficient.

There are different theories on this subject but we maintain that we have found the balance between air volume and velocity that provides optimal efficiency. Furthermore, high speed causes high sound levels and turbulence and large air volumes require a lot of heat.

Sound level
Frico focuses strongly on sound levels and we work constantly on improvements. The kind of fans we use and the overall optimisation in air flow geometry also result in optimized sound levels. Sound is an important environmental factor, equally as important as good light, fresh air and ergonomics. Awareness of and demands for lower sound levels are increasing. At Frico we take responsibility for this and limit the effects our products have on overall sound levels. Read more about sound on page 244.

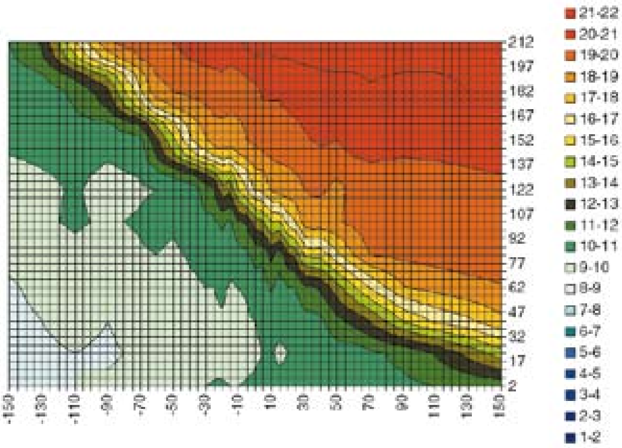
On the following pages you can read more about tests that illustrate Thermozone technology.

THERMOZONE® TECHNOLOGY

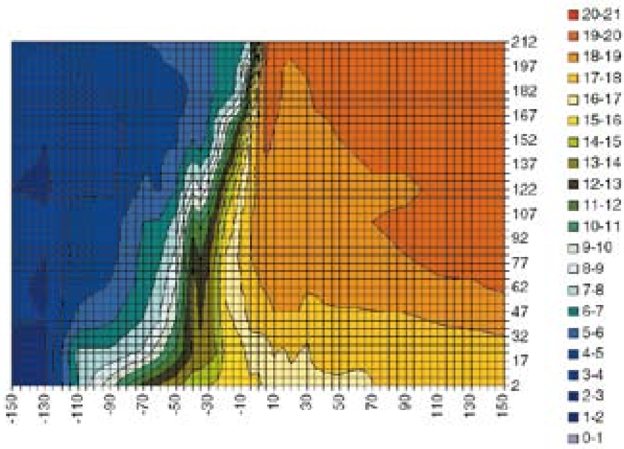
The invisible door

The simulated environment was a cold storage area in a food store where dairy products are held. The area had a direct connection with normal room temperature. By carrying out a set of tests at different conditions and by measuring the temperature at different points in the air stream, the following charts were generated, showing how the airflow can effect the temperature in the different areas around the opening.

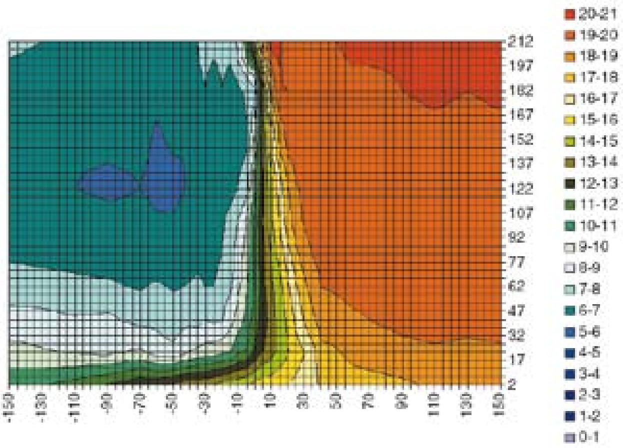
The dark red colour shows room temperature and the darkest blue colour the lowest cold-storage temperature. The value on the x-axis indicates the distance in centimetres from the unit, the value on the y-axis indicates the distance in centimetres from the floor. To the right of each diagram is a key to the colours/ temperature relationship.



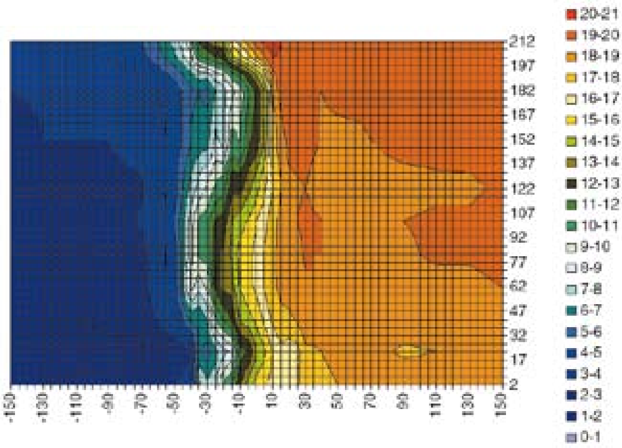
Opening without air curtain
In an opening without protection you can see how the cold air escapes through the opening, resulting in a significant amount of warm air ingress.



Opening with an air curtain set at the wrong angle
If the angle is too small, warm air will blow in to the cold storage and result in increased internal temperature and subsequent energy loss.



Opening with an air curtain, velocity too high
The airflow is an important factor in achieving a good result with an air curtain. Excessive velocity will result in energy loss and an increase in the cold storage temperature.



Opening with a correctly adjusted air curtain
With the air curtain correctly set-up a sharp separation is made between the temperature zones.

The test was carried out using Thermozone ADA Cool, model ADAC120, by Malmö Technical University, Sweden.

Performance

Separating climate zones where only the temperature differs is relatively easy. Handling an opening that is exposed in terms of wind and pressure differences i.e. unbalanced ventilation (read more on pages 190-191) is more difficult. Our aim is to counteract these problems by achieving the optimal balance between air volume and air velocity. Not only does this balance make the air curtain more efficient, but it also provides other advantages such as a comfortable indoor climate with less noise and turbulence. Energy costs are reduced at the same time.

There are different theories on this subject, but supported by our tests, we maintain that we have found the balance that provides optimal efficiency combined with low energy consumption. High velocities require a lot of energy to build up the necessary pressure. Large air volumes also require a lot of energy.

Impulse and air velocity are important factors when talking about air curtain performance. The impulse is the mass flow (air volume x density) multiplied by the velocity and it can be created in different ways. A unit with high air velocity and a small airflow can have the same impulse as a unit with low air velocity and a large airflow.

If airflow and air velocity are optimized the air curtain can perform better than units with higher impulse or higher air velocity. The air velocity profiles shown in the catalogue are based on measurements done in a laboratory environment with a hot-wire probe instrument, using recognised test methods, the figures represent peak levels.

Performance test

Frico has developed a method for testing the performance of air curtains. The test described below was carried out as a full scale test. The idea is to compare the air volume that passes through a door with and without an air curtain. The testing facility used is described in Fig. 1. The two rooms correspond to outdoor and indoor environments. There are two ducts equipped with airflow measuring devices between the two rooms. An axial fan is mounted in the end of each duct. The air curtain is installed above the opening.

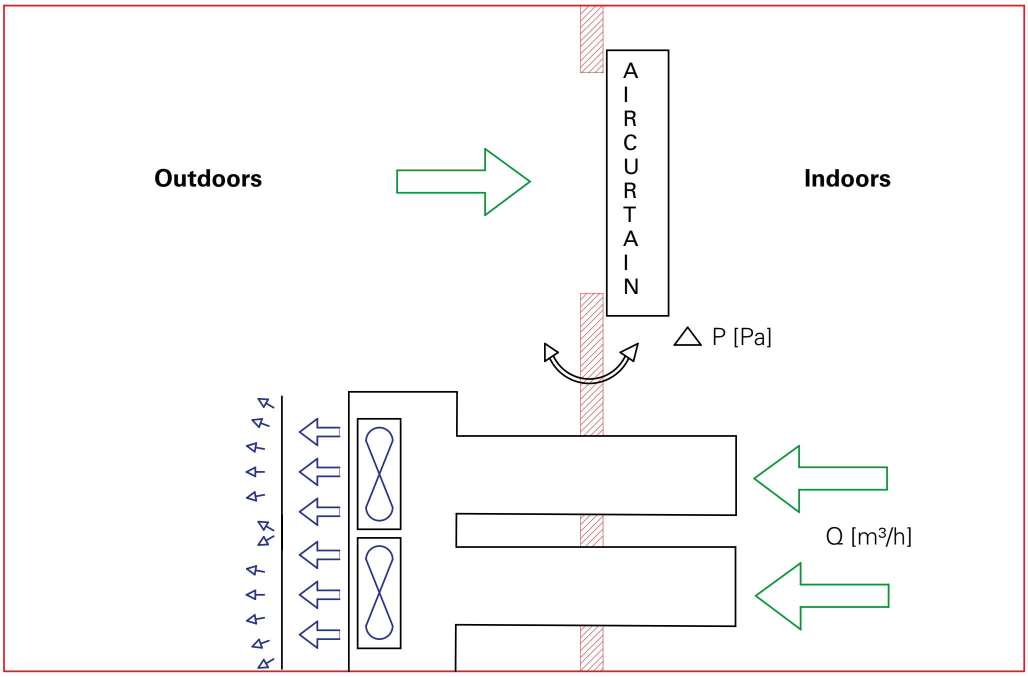


Fig. 1 Testing facility

When the fans are running airflow is created from the indoor to the outdoor environment and the exact same air volume passes through the ducts as through the opening. This creates a pressure difference ((DP) between the two rooms. The fans start at a low speed which is gradually increased. In the meantime information on airflow and pressure differences is stored in a computer. A curve is created from the data and this is shown in Fig. 2 below. The opening is measured with and without an air curtain. The result is two curves on which the airflow at a certain pressure difference can be compared.

Example: At 3 Pa the airflow through the opening without an air curtain is 4 m^3/s and 1,6 m^3/s with an air curtain. The difference in airflow shows the efficiency of the air curtain. In this case there is (4-1,6)/4*100 = 60% less flow with an air curtain than without.

This makes it possible to compare the performance of different products under the same circumstances. Fig. 3 shows the result of tests of units constructed on different principles. Type 1 has high air velocity and small airflow, type 2 has medium air velocity, a large airflow and a Thermozone with optimized air velocity and airflow. The Thermozone is more efficient than the type 2 unit even though it has 13% lower impulse.

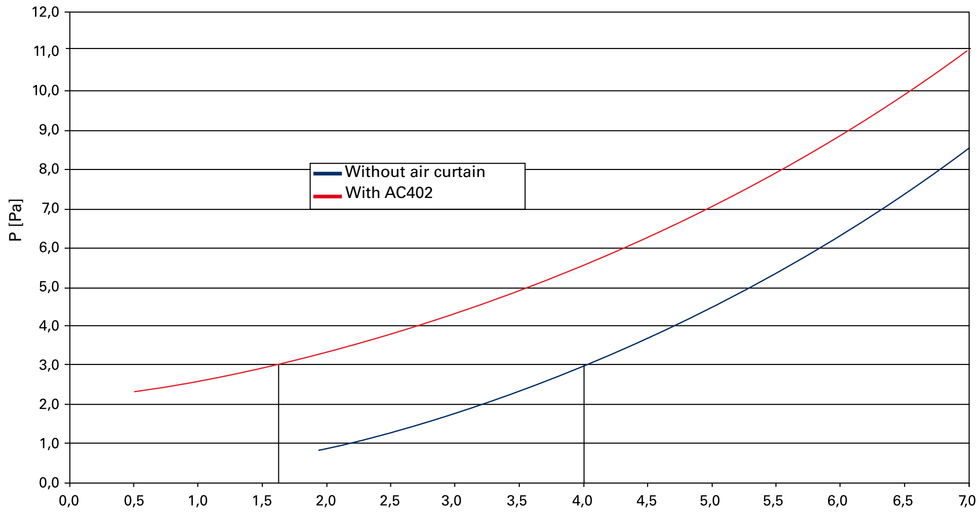


Fig. 2. Airflow through the opening, with and without air curtain at different pressures

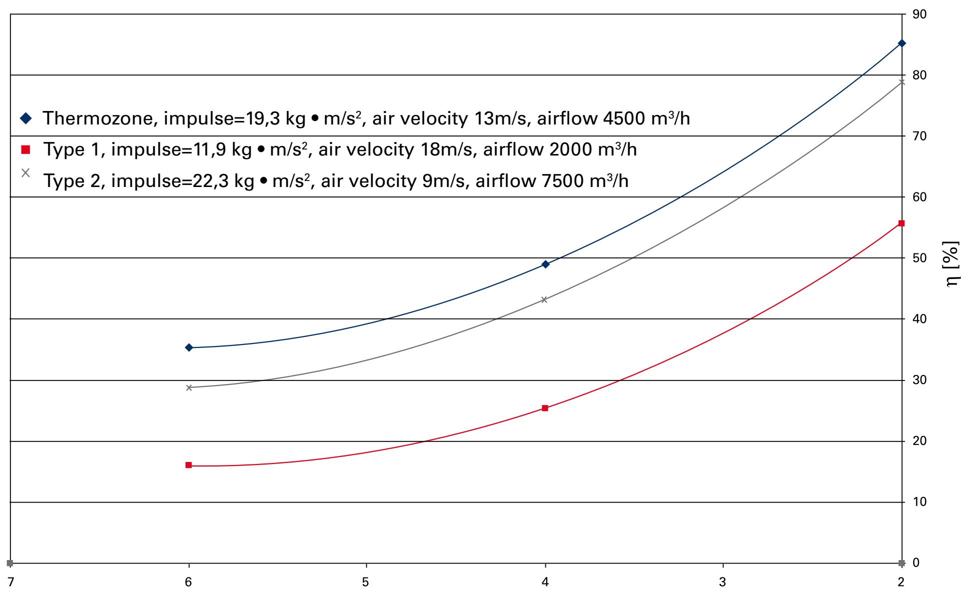


Fig. 3. Air curtains mounted on 3 metres height, efficiency at different pressures

Sound

Sound is an important environmental factor, equally important as good light, fresh air and ergonomics. What we usually call the sound level of a product is actually the sound pressure level. The sound pressure level includes the distance to the sound source, the position of the sound source and acoustics of the room. This means that a silent product is essential, but the whole environment needs to be considered to achieve a comfortable sound level.

What is sound?

Sound is caused by air pressure fluctuations that evolve when a sound source vibrates. The sound waves that are produced are condensation and dillusion of air particles without the air in itself moving. A sound wave can have different velocities in different media. In air the sound has a velocity of 340 m/s.

How is sound measured?

Sound level is measured in decibel (dB). The dB is a logarithmic unit used to describe a ratio. If the sound level is increased by 10 dB, the result is twice as loud (matematically it is 6 dB, but the way we hear it, it is 10 dB).

It is also useful to know that two equally strong sound sources give an added sound level of 3 dB. Assume you have two entrances with two air curtains in each entrance, all four units with a sound level of 50 dB. The total sound level will then be 56 dB. The first opening will have a total sound level of 53 dB plus an extra 3 dB from the other opening.

Points of reference – dB

0	The softest sound a person can hear
10	Normal breathing
30	Recommended max. level for bedrooms
40	Quiet office, library
50	Large office
60	Normal conversation
80	Ringing telephone
85	Noisy restaurant
110	Shouting in ear
120	The threshold of pain

Fundamental concepts

Sound pressure

Pressure develops when pressure waves move, for example in the air. The sound pressure is measured in Pascals (Pa). To clarify sound pressure a logarithmic scale is used which is based on the differences between the actual sound pressure level and the sound pressure at the threshold of hearing. The scale has the units decibels (dB), where the threshold of hearing is 0 dB and the threshold of pain is 120 dB.

The sound pressure decreases with the distance from the source and is also affected by the acoustics of the room.

Sound power

Sound power is the energy per time unit (Watt), which the object emits. Sound power is calculated from the sound pressure and also uses a logarithmic scale. Sound power is not dependent on the sound source nor the acoustics of the room, which therefore simplifies the comparisons of different objects.

Frequency

A sound source's periodical oscillation is its frequency. Frequency is measured as the number of oscillations per second, where one oscillation per second is 1 Hertz (Hz).

Sound power level and sound pressure level

If the sound source emits a certain sound power level, the following will affect the sound pressure level:

1. Direction factor, Q

   Specifies how the sound is distributed around the sound source. See figure below.

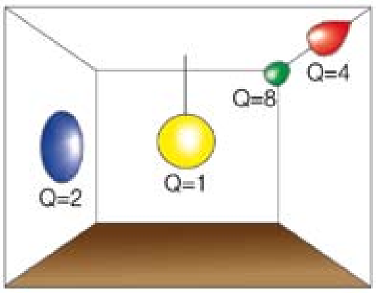
2. Distance from sound source

   The distance from the sound source in metres.

3. The rooms equivalent absorption area

   The ability for a surface to absorb sound can be expressed as an absorption factor, α, which has a value between 0 and 1. The value 1 corresponding to a fully absorbing surface and the value 0 to a fully reflective surface. The equivalent absorption area of a room is expressed in m^2. This can be calculated by multiplying the room's surface area by the surfaces' absorption factor.

With these known factors it is possible to calculate the sound pressure if the sound power level is known.



The distribution of sound around the sound source.

Q = 1	Middle of room
Q = 2	On wall or roof
Q = 4	Between wall and roof
Q = 8	In corner

Table and diagrams for dimensioning

Basic electrical formulas

Amperage

Direct current and single-phase alternating current at cosφ=1	3-phase alternating current Y-connection	3-phase alternating current Δ-connection
$I=U/R=P/U$	$I_f=I$	$I=I_f\sqrt{3}$

Voltage

Direct current and single-phase alternating current at cosφ=1	3-phase alternating current Y-connection	3-phase alternating current Δ-connection
$U=RI$	$U=U_f\sqrt{3}$	$U_f=U$

Power

Direct current and single-phase alternating current at cosφ=1	3-phase alternating current Y-connection	3-phase alternating current Δ-connection
$P=UI$	$P=\sqrt{3}UI\cos\varphi$	$P=\sqrt{3}\,UI\cos\varphi$

U = operating voltage in volts: with direct current and 1-phase alternating current between the two conductors, with 3-phase alternating current two phases (not between phase and zero).
U_f = voltage between phase and zero in a three-phase cable.
$\sqrt{3} \cong 1.73$
I = current in ampere
I_f = current in ampere in phase wire
R = resistance in ohm
P = power in watts

Symbols for model types

= normal design (no symbols), IPX0
= drip-proof design, IPX1
= splash-proof design, IPX4
= jet-proof design, IPX5

Protection classes for electrical material

IP, first figure	Protection against solid objects
0	No protection
1	Protection against solid objects ≥50 mm
2	Protection against solid objects ≥12.5 mm
3	Protection against solid objects ≥2.5 mm
4	Protection against solid objects ≥1.0 mm
5	Protection against dust
6	Dust-tight

IP, second figure	Protection against water
0	No protection
1	Protection against vertically dripping water
2	Protection against dripping water angled at max 15°
3	Protection against sprinkled water
4	Protection against spraying with water
5	Protection against water jets
6	Protection against heavy seas
7	Protection against short-term immersion in water
8	Protection against the effects of long-term immersion in water

Dimensioning table for cables and wires

Installation wires, open or in conduit		Connection wires		
Area [mm²]	Fuse [A]	Area [mm²]	Continuous current [A]	Fuse [A]
1,5	10	0,75	6	10
2,5	16	1	10	10
4	20			
6	25	1,5	16	16
10	35	2,5	25	20
16	63	4	32	25
25	80	6	40	35
35	100	10	63	63
50	125			
70	160			
95	200			
120	250			
150	250			
185	315			
240	315			
300	400			
400	500			

Dimensioning table

Amperage at different powers and voltages

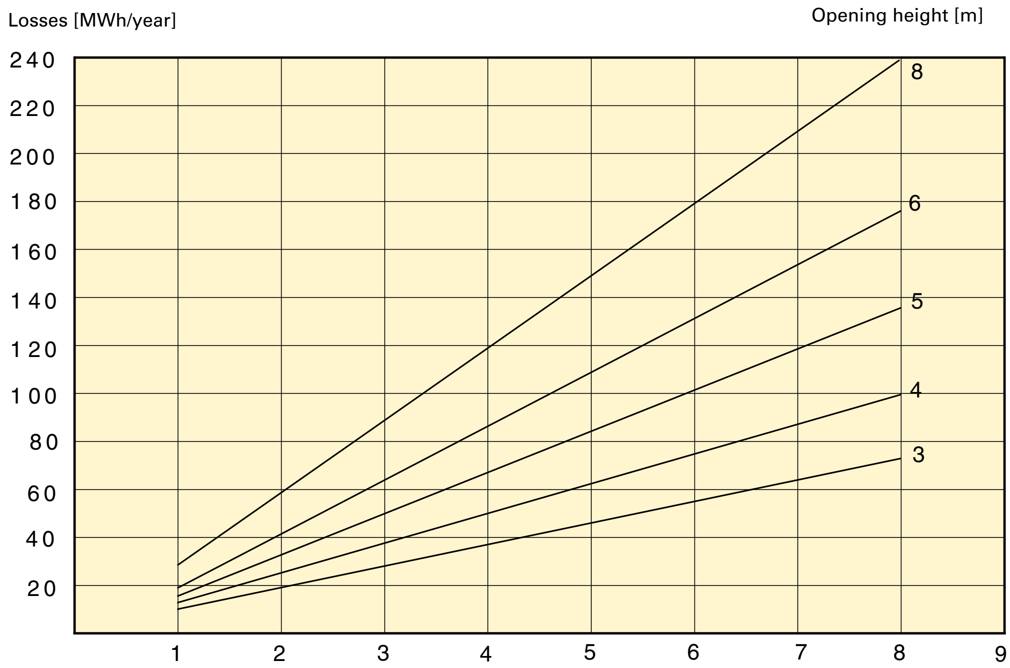
Power	Voltage [V]					
[kW]	127/1	230/1	400/1	230/3	400/3	500/3
1.0	7,85	4,34	2,50	2,51	1,46	1,16
1.1	8,65	4,78	2,75	2,76	1,59	1,27
1.2	9,45	5,22	3,00	3,02	1,73	1,39
1.3	10,2	5,65	3,25	3,27	1,88	1,50
1.4	11,0	6,09	3,50	3,52	2,02	1,62
1.5	11,8	6,52	3,75	3,77	2,17	1,73
1.6	12,6	6,96	4,00	4,02	2,31	1,85
1.7	13,4	7,39	4,25	4,27	2,46	1,96
1.8	14,2	7,83	4,50	4,52	2,60	2,08
1.9	15,0	8,26	4,75	4,78	2,75	2,20
2.0	15,8	8,70	5,00	5,03	2,89	2,31
2.2	17,3	9,67	5,50	5,53	3,18	2,54
2.3	18,1	10,0	5,75	5,78	3,32	2,66
2.4	18,9	10,4	6,00	6,03	3,47	2,77
2.6	20,5	11,3	6,50	6,53	3,76	3,01
2.8	22,0	12,2	7,00	7,03	4,05	3,24
3.0	23,6	13,0	7,50	7,54	4,34	3,47
3.2	25,2	13,9	8,00	8,04	4,62	3,70
3.4	26,8	14,8	8,50	8,54	4,91	3,93
3.6	28,4	15,7	9,00	0,05	5,20	4,15
3.8	29,9	16,5	9,50	9,55	5,49	4,39
4.0	31,15	17,4	10,0	10,05	5,78	4,62
4.5	35,4	19,6	11,25	11,31	6,50	5,20
5.0	39,4	21,7	12,50	12,57	7,23	5,78
5.5	43,3	23,9	13,75	13,82	7,95	6,36
6.0	47,3	26,1	15,0	15,1	8,67	6,94
6.5	51,2	28,3	16,25	16,3	9,39	7,51
7.0	55,0	30,4	17,50	17,6	10,1	8,09
7.5	59,0	32,6	18,75	18,8	10,8	8,67
8.0	63,0	34,8	20,0	20,1	11,6	9,25
8.5	67,0	37,0	21,25	21,4	12,3	9,83
9.0	71,0	39,1	22,5	22,6	13,0	10,4
9.5	75,0	41,3	23,75	23,9	13,7	11,0
10.0	78,5	43,5	25,0	25,1	14,5	11,6

For power outputs between 0,1 and 1 kW, the amperage read is multiplied by 0,1. For power outputs between 10 and 100 kW, the amperage read is multiplied by 10.

Energy savings with air curtains

The diagram below shows how big the energy losses can be through a door without air curtains as protection.

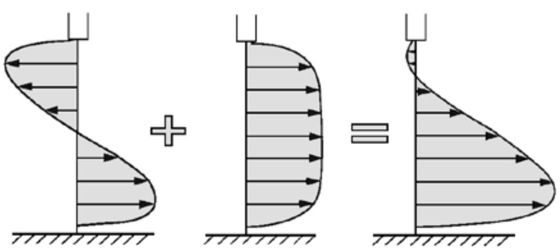
Assumptions:	Large room	
	Average annual temperature	6,5 °C
	Average annual wind velocity υ_{10}	4 m/s
	Duration of open door	1 hr/day



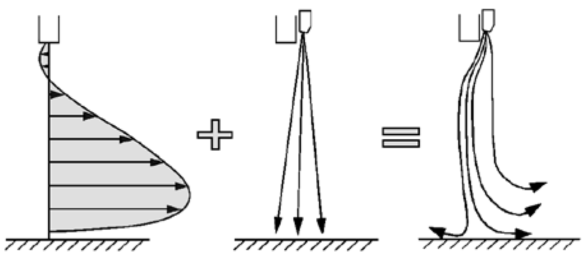
Energy losses through an unprotected opening

Several factors affect air exchange and energy losses through an opening. The main factors are the size of the opening, the frequency of the traffic and the stress in terms of wind as well as temperature and pressure differences.

With an air curtain installed inside the opening you limit the energy losses, the amount saved depends on the character of the opening. Overleaf is an example showing some given factors and an estimated saving.



The stress on the door is caused by temperature and pressure differences and wind.



The stress on the opening counteracted by an air curtain.

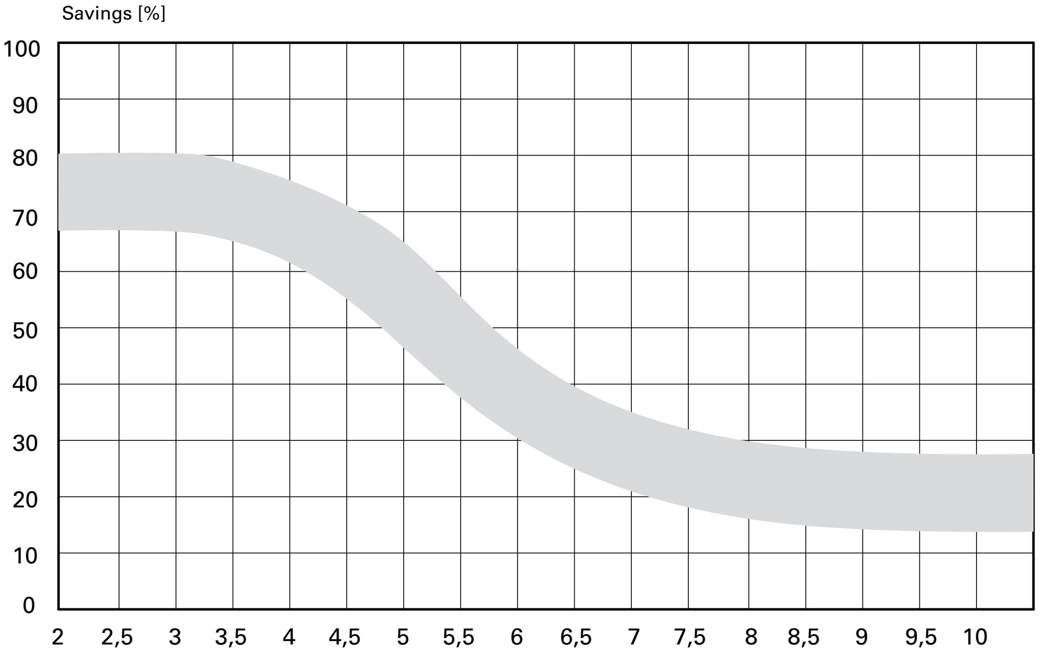
Calculation on energy savings

Door height	5	m
Door width	4	m
Days per week in operation	5	days
Open time per 24 hours	1	h/24
Duration of each opening of door	5	min/opening
Dim. indoor temperature	18	°C
Dim. outdoor temperature	-18	°C
Average annual temperature	5	°C
Wind velocity	4	m/s
Volume of the room	6400	m^3

We will compare the energy losses through an open, unprotected door to an equivalent door with air curtains installed. The calculations should be seen as guidelines. Calculations on energy savings is no exact science, it is difficult to determine the effect of draughts, how well sealed the building is, the stack effect, the wind speed and direction etc. What we can see, however, is that the energy losses are high if an opening is left unprotected.

If we compare the values in the diagram on the previous page with the diagram below we can see that the air curtain eliminates up to 65% of the air exchange through the door.

Energy losses, unprotected opening:	69 MWh/yr
Energy losses, opening with air curtain:	24 MWh/yr
Energy savings:	45 MWh/yr



Estimated energy savings (efficiency) gained with air curtains for openings of different heights compared to equivalent unprotected openings.

Contact Frico

You are very welcome to contact us to discuss conditions in your opening. With some information from you we can estimate possible energy savings. See check list to the right with useful parameters.

- The width and height of the door
- Type and size of premises
- Days per week in operation
- Open time per 24 hours
- Indoor and outdoor temperature
- Wind exposure
- Under pressure

Why is there draught from an open door?

A door needs to be opened to let people and vehicles pass through. An open door also attracts more customers. The drawback is cold draughts and energy losses. The amount of air that leaks out through an open door depends on the pressure difference between the indoor and outdoor air.

The airflow through an opening is caused by three factors:

- Pressure difference outdoors/indoors
- Temperature difference outdoors/indoors
- Wind velocity at the opening

Simply put you could say that if the conditions on each side of the door differ in any way, than there will be a draught through the doors. Air leaks out through an open door to level out the differences in pressure and temperature. In a heated room this means that warm air leaks out and is replaced by cold air. Wind blowing towards the opening also affects the airflow.

Airflow due to pressure differences

For an air curtain to function at optimum efficiency it is important that the over or under pressure in the building is not too large. The pressure difference between the building and its surroundings can be eliminated with balanced ventilation which counteracts the airflow resulting from pressure differences between internal and external air.

Ventilation systems are generally so called zero pressure systems that are mechanically tuned and based on conditions at the time of adjustment. When conditions change, through variations in temperature, air pressure, wind effect or humidity, the balance of the zero pressure system will result in either an over or under pressure in the building (usually under pressure).

An air curtain can withstand 5 Pa pressure difference as a maximum, depending on the circumstances. Even lower pressure differences could considerably affect the efficiency of the air curtain.

With balanced ventilation, comfort levels are raised and energy costs reduced. Balanced ventilation can be obtained with pressure regulation through the ventilation system, although the most efficient way is to continuously measure the pressure difference between the internal and external air and regulate the ventilation based on this data. Contact us for more information. The airflow due to pressure difference, Q_P, can be calculated thus:

$$Q_P = W \bullet H \bullet \sqrt{\frac{\Delta P \bullet 2}{\rho}} \bullet 0{,}8 \qquad [1]$$

($\Delta P \leq 5$ Pa)

where
W = Width of the door [m]
H = Height of the door [m]
ΔP = Pressure differences
ρ = Density of the air

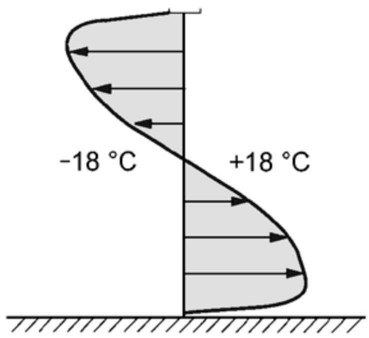
Airflow due to temperature differences

Warm internal air is less dense and lighter than cold out door air, causing a pressure difference at the opening. The cold outside air streams in at the bottom of the opening and forces out warm air through the upper part of the doorway. This is referred to as the opening ”breathing.”The size of the airflow varies according to the differences in temperature between internal and external air. The air exchange is therefore said to be caused by thermal temperature differences. Using known values for the temperatures in the building as well as outdoors, the density of the air masses can be calculated and thereby also the pressure differences and the airflow through the opening.

The airflow, Q_T, can be calculated thus:

$$Q_T = \frac{W}{3} \bullet H^{1.5} \bullet \mu_0 \bullet \sqrt{g \bullet \frac{\Delta\rho}{\rho_m}} \qquad [2]$$

where
W = Width of the door [m]
H = Height of the door [m]
μ_0 = Flow coefficient (0,1-1,0)
g = Gravitation coefficient (9,81 m/s²)
$\Delta\rho$ = Density differences between the air masses
ρ_m = Average density of the air masses



Airflow due to thermal pressure differences

Wind stress

When the wind blows against the doorway, air streams through the opening. The air stream is evenly distributed over the entire opening. The size of the airflow is thus proportional to the wind velocity at a right angle to the opening. (After a time, the room will have such a great overpressure that the airflow will be limited to what leaks out through unsealed areas of the building.) A wind velocity of 3 m/s equals a load pressure of 5 Pa.

Airflow due to wind stress, Q_V, can be calculated thus:

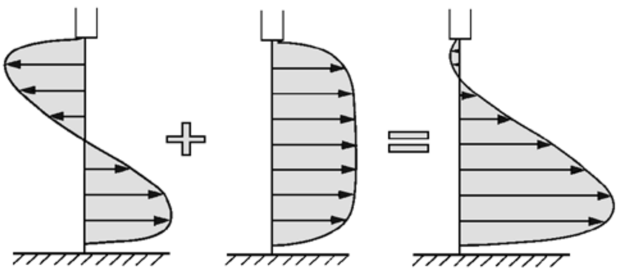
$$Q_v = W \bullet H \bullet \frac{\upsilon_{10}}{2} \bullet 0{,}25 \times L \qquad [3]$$

where	W	=	Width of the door
	H	=	Height of the door
	υ_{10}	=	Average yearly velocity at a ht. of 10 metres (see climate data)
	0,25	=	Wind direction frequency factor
	L	=	Position factor, 1 = normal value, >1 for subjected position

Total airflow

Total airflow through the opening is the sum of the flow due to temperature and pressure differences and the flow due to wind stress.

$$Q_{tot} = Q_T + Q_V + Q_P \qquad [4]$$



Total airflow

Important notes

- If there is negative pressure in the room the performance of the air curtains will be substantially reduced, the ventilation should therefore be balanced. An air curtain can not block a deficit in the amount of air (under pressure) caused by an unbalanced ventilation. Mechanical fans are always more powerful than any jet of air.

- If an opening is exposed to wind, this affects the efficiency of the air curtain. An air curtain may withstand a wind velocity of 3 m/s as a maximum, depending on the circumstances. In openings highly exposed to wind more heat can be added. For new constructions it is advisable to consider relocating the opening or adding a revolving door or double door, preferrably with the openings not in a straight line.

- In most cases the air curtain unit should be placed on the inside of the opening it is meant to protect. When protecting a cold room however it is positioned on the warm side.

- To obtain optimal air curtain performance the air curtain should be placed as close to the opening as possible and cover the whole width of the opening.

- The direction and speed of the air stream should be adjusted according to the characteristics of the doorway. Wind pressure affects the air curtain's performance and tends to bend the air stream inwards. The air current should therefore be angled outwards.